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Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

R&D ACTIVITIES ON REFRACTORIES AT CANMET

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Resource Utilization Laboratory

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by

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ABSTRACT

An overview of the past and present activities in the field of refractory research in CANMET is presented. Other topics that focus on the organization and facilities of CANMET are also briefly discussed.

Keywords: Ceramics, Refractories, R&D

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INTRODUCTION

The Canada Centre for Mineral and Energy Technology (CANMET) is the research and development arm of Energy, Mines and Resources Canada. In partnership with industry, CANMET performs predominantly commercial and cost-shared R&D, and technology transfer, with the following mandate:

- to enhance the competitiveness of the Canadian minerals, metals and energy industries by supporting their R&D activities;
- to improve health, safety and environmental control in the industries; and
- to support government policy initiatives.

The current organization of CANMET consists of the five major laboratories with technical and support staff of approximately 700. These five laboratories are:

- Mineral Sciences Laboratories (MSL)
- Metals Technology Laboratories (MTL)
- Energy Research Laboratories (ERL)
- Mining Research Laboratories (MRL) and
- Coal Research Laboratories (CRL).

These are located in various regions of Canada, but the bulk of the staff and facilities are at the Booth Street and Bells Corners complexes in Ottawa. Among these laboratories the activities of MSL are of the most direct interest to the refractory industry. Since 1988, CANMET has been mandated to perform predominantly commercial and cost-shared R&D, cost recovery and industrial technology transfer. In response to this mandate MSL is focusing its work according to industrial needs and re-organizing it from a discipline-based to a program-based matrix management system. In other words, the MSL's resource was pooled in three program areas and R&D projects under the programs are carried out by a

project team assigned from the resource pools. MSL identified three program areas as:

- Resource Utilization
- Environmental Protection, and
- Core Technology Laboratory

The Resource Utilization Laboratory in MSL comprises the mineralogy, concrete technology, mineral processing and Ceramics Groups. These four areas cover a wide spectrum of activities related to the ore dressing, beneficiation, characterization, processing, waste recycle and exploitation of a range of inorganic non-metallic minerals and materials.

THE WORK OF THE CERAMICS GROUP

Historically R&D programs in both traditional and advanced ceramics have been carried out by the Ceramics Section of the Mineral Sciences Laboratories located in the "Booth Street Complex" of CANMET at 405 Rochester Street, Ottawa. Evolving under the original Mines and Technical Surveys Division, the initial activities of the Section in the 1920's centred on the laboratory evaluation of naturally-occurring materials from deposits discovered and sampled by the Survey's field parties. Consequently, the Section has had a long and close association with the traditional ceramic field, particularly with the characterization, processing and evaluation of clay and shale products, that has continued over 60 years.

With the continued exploration and discovery of more refractory materials, coupled with the progressive industrialization of the country, it was natural that the technology of pressed and extruded clay and shale products would be extended to the examination of deposits thought suitable for industrial refractory applications. This activity continued until the mid 1970's; since then the section has been primarily involved with the characterization of commercial refractories, particularly those used in speciality-steel making. For many years the Group has been extensively involved in the process development and characterization of ceramic materials, and has maintained expertise in the refractory field through both in-house R&D

programs and collaborative studies with industrial partners under cost shared agreements leading to technologies of interest to industry. The Group includes expertise in refractories fabrication, slag chemistry and microstructural analyses as well as electrical and mechanical properties measurements. There is a trend towards higher and higher operating temperatures in many metallurgical processes. This has resulted in an increased need for more durable materials particularly as corrosion and erosion phenomena become of crucial importance. Work in highly refractory ceramics was initiated in 1968 by the development of reactive alumina; in 1970 work commenced on stabilized and partially stabilized zirconias and in 1985, work on SiC also started. Increasingly, non-silicate systems have been examined in recent years as well as oxide and non-oxide composite materials.

The evolution of the work in advanced ceramics has been occurring progressively since the late 1950's. The work in advanced functional ceramics has become dominant in the Section through the 1970's and 1980's in such areas as magnetic ferrites, piezo-electric ceramics, ultrasonic NDT work, beta-aluminas and Nasicon for ion-conducting ceramics.

In 1989, the Group launched a program called "C-cubed" (CANMET Ceramics Consulting) to serve Canadian industries. The program operates for member companies purchasing "time credit" with CANMET which they can redeem over the course of a year as they see fit. In this manner, the companies have maximum flexibility; they can switch from a literature survey, to failure analysis, to solving production problems, or to development of new products, all within a single initial time credit of 46 hours for $5000 (incl. GST). This eliminates major paper work in contractual obligations should they wish to redirect the work.

The highlights of the R&D work carried out by the Group on refractories are following:

1955	Developing Mullite Refractories from Canadian Kyanite
1962	The Plasticity of Queenstone Shale
1962	The Effect of Composition of Whitemud Formation Clays on their Utilization

1963	Dense Lithium Fluoride for Gamma Ray-Free Neutron Shielding (used by AECL, Chalk River Labs)
1964-68	Ceramic Clays & Shales of British Columbia, Quebec and Atlantic provinces
1965	The Influence of Lime on the Firing Behaviour of Clays and Shales (Clay Products Industry, Ontario)
1965	Developing Improved Comparative Method Apparatus for Measurement of Thermal Conductivity of Solids
1969	Non-metallic Thermal Storage Media for Electric Space Heaters
1969	Refractory Grade Magnesia from an Ontario Source
1971	Publishing Survey of Canadian Minerals for Refractories
1970-71	Characterization of Reactive Alpha-Alumina from Commercial Raw Material (Co-operative program with Alcan)
1971	Development of Freeze-Dried Ceramic Raw Materials
1970-74	Development and Demonstration of Oxygen Probe for Use in Steel-making Furnaces (Joint program with Leigh Instruments and U of T)
1974	Recovery of Waste Heat in the Production of Expanded Shale Aggregate (Domtar Construction Materials)
1976-79	Extraction of Alumina from Domestic Anorthite and Clays
1979	Effect of Temperature on Degradation of High-alumina Castables
1980-83	Release of Lead from Canadian Pottery Glazes
1980-84	Developing Technique for High-temperature Viscosity Measurement (Optimization of melts for mineral wool fabrication)
1983	Establishing Optimized Induration Conditions for Iron Ore Pellets
1984	Examination of Nozzle Refractories for VAD/VOD Ladles
1984	Developing Acceptance Test Method for Steel-making Carbon Electrodes

1985	Demonstrating Iron Ore Pelletization by Cold Extrusion
1985	Organic and Inorganic Binders for Iron Ore Extrusion
1986	Comparative Degradation of Dolomite Bricks in VAD/VOD Service

The projects in the period of 1987-to date are not listed above in order to protect confidentiality of clients.

PRESENT FACILITIES

The Ceramic Group has access to a wide range of facilities ranging from extensive analytical services in the chemical lab to a range of electron-optic facilities that are available in both the Metals Technology Laboratories and our own Mineralogy Group. A wide range of powder characterization facilities are also available in MSL for the determination of particle size and size distribution (Coulter Counter, Micrometrics Sedigraph, Quantimet), surface area (Quantachrome) and surface charge (Zeta-meter). Equipment for DTA, TGA, IR spectra, Hot-stage microscope (1700°C), colour (Hunter meter), structure (X-ray diffraction) are also available.

The Group is well equipped in lab-scale facilities in ceramic powder synthesis, characterization, fabrication and sintering. Ceramic processing is one of the Group's strength. Ceramic forming facilities available in the Group include a vacuum extruder, conventional uniaxial and isostatic presses, vacuum hot press to over 2000°C, slip casting and injection moulding equipment. Sintering capability is provided by the usual range of electrical resistance furnaces having either Kanthal (1250°C), Silicon Carbide (1450°C), Super Kanthal (1650°C), platinum/rhodium (1700°C) or zirconia (2000°C) for operation in air and graphite elements for operation to 2600°C in a protective atmosphere. A 30-KW induction furnace is also available. The facilities for mechanical testing available in the Group include 4-point bending to 1500°C and hardness and toughness by indentation. The Group also has facility for the determination of pyro-viscosity up to 1800°C. The full range

of casting, curing and testing facilities for castable refractories are available in the Concrete Group. More detailed information of the recent activities of the Ceramics Group can be found in the 1989/90 Annual Report of the Mineral Sciences Laboratories (1) and Division Report (2).

REFERENCES

1. Mineral Sciences Laboratories 1989/90 Annual Report available from Technical Information Division, CANMET, 555 Booth Street, Ottawa K1A 0G1.
2. T.A. Wheat "Ceramics Activities at CANMET" Division Report MSL 86-145 (OP&J).